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Air Driven Sonic Microoscillating Instruments in Bone Regeneration Procedures: Overview of Settings and Clinical Applications

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ABSTRACT
Minimally invasive instrumentation is increasingly central to modern dentistry, with growing emphasis on precision, safety, and tissue preservation across all specialties. While rotary instruments (RIs) and ultrasonic instruments (UIs) have long been standard in clinical practice, sonic instruments (SIs) have recently emerged as a valuable alternative. This study reports on a large case series involving over XXX patients, representing one of the most extensive clinical assessments of SI use in dentistry to date. Procedures spanned multiple disciplines, including conservative dentistry, endodontics, prosthodontics, periodontology, oral surgery, and implantology.
Compared to US instruments there is a lack of knowledge about use of sonic instruments in bone regeneration procedures. Aim of this study is to demonstrate their applicability in various fields of surgical bone regeneration procedures , detailing their specifications and settings .
Within the limits of this study, sonic instruments emerge as a safe, accurate, and versatile tool in bone regeneration procedures, supporting minimally invasive protocols and expanding clinical capabilities across oral surgery and regenerative medicine.
Keywords: Sonic handpiece 1; Oral Surgery 2; Ultrasonic 3

I. INTRODUCTION

Since the 1950s, dentistry's ultrasonic instruments have developed rapidly. Because of better visualization, operative convenience, and precise cutting ability, ultrasonic instruments have widely and efficiently applied in the dental field. Ultrasonic instruments have been applied successfully in periodontology, endodontics, orthodontics, dental surgery in operative and prosthodontic dentistry, pedodontics [1][2]

Previous studies indicate that ultrasonic instruments have a high potential to become convenient and efficient dental tools and deserve further development, although some issues. [1]

Not only ultrasonic, but also sonic devices are commonly used in dental practices such as, periodontology endodontics, prosthetics and also oral surgery. [2]

SI operates at frequencies of 2 to 6 kHz and is powered by pressurised air from the dental unit. Variables likely to affect how these instruments perform include the air pressure input and load applied by the operator. Other variables include the brand of sealer used and the clinical technique of the operator. [3]

Clinical studies have shown that ultrasonic and sonic techniques can provide a clear view of the surgical field, leading to reduced damage to essential anatomic structures such as the nerves or blood vessels ,reduced damage to the tissue wound leads to faster healing. [4][5], [6]

In bone regeneration osteotomy is an essential step in the surgical procedure surgery ,providing access to the native bone . Its application can influence the final outcome. [7] Nowadays, the conventional burr reduction is being challenged by newer promising sonic and ultrasonic methods.[7]

The increased bone formation in cases of ultrasonic and sonic knife surgery may be due to the reduced damage to the mother bone, possibly due to the sustained bone-forming activity of osteoblasts.[4]
Sonic instruments show almost no signs of thermal injuries on the osteotomized bone surfaces in several recent studies [8][5]

SINUS LIFT

Several techniques have been proposed to manage patients with insufficient bone height for

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implant placement in the posterior maxilla. The lateral approach to sinus elevation is a successful procedure, unfortunately, a frequent complication encountered during sinus elevation procedure is perforation of the Schneiderian membrane. Several authors suggest the application various shape tips and an air-driven sonic instrument, for the preparation of the lateral window osteotomy during sinus augmentation procedures.[6]

In other studies the use of a sonic instrument to prepare the lateral window osteotomy during sinus elevation procedures resulted in a reduced perforation rate of the Schneiderian membrane compared with conventional rotary surgical instruments.[9]

BONE GRAFTING HARVESTING AND FIXATION

Ultrasonic and sonic devices, are used in bone grafting procedures for their precision and ability to minimize damage to surrounding tissues. In bone synthesis techniques ultrasonic instruments are actually used for pin positioning and for conservative removal of distraction devices in oral surgery and cranio-maxillofacial surgery [10][5]

BONE EXPANSION

In edentulous ridge expansion sonic instruments can be applied due to their precision and selective cut [11]

There is actually a lack of knowledge about possibility to use sonic instruments instead of ultrasonic for most of supracited applications

Aim of our work is to describe through a case series an overview of possible applications of air driven micro-oscillating sonic instruments in bone regeneration procedures, detailing use of sonic handles, tips and their settings for specifical procedures and investigating for complications.

II. MATERIALS AND METHODS

41 patients (29-81 y.o.) have been treated for oral surgery bone regeneration procedures including bone grafting sinus lifting, bone harvesting, bone fixation and expansion (Table 1).

Table 1 Bone regeneration procedures

BONE REGENERATION PROCEDURES
BONE GRAFTING (bone perforation in GBR, graft condensation)
SINUS LIFT LA
SINUS LIFT CA
BONE FIXATION
BONE BLOCK HARVESTING
BONE CHIPS HARVESTING
BONE EXPANSION

Sonic handpiece and sonic tips instruments have been used both for flap elevation, bone surgery, bone harvesting, and for fixation screws tunnel preparation when used. Instruments used are described below.

SONIC HANDPIECE:

Sonic handpieces were used on a turbine Multiflex type quick coupling. Air pressure set on turbine cable, depending on producer's recommended setting (measured before starting the treatment with a turbine cord manometer) ranged between 2.5bar -and 3.5 bar. Quick coupling connector was attached to turbine cord of dental chair. (Figure 1)

- Quick coupling surgical sonic handle with 5000 Hz to 6500 Hz oscillating frequency (SF1L/M Komet Italia).
- Quick coupling surgical sonic handle with 5000 Hz to 6500 Hz oscillating frequency. (SONOSURGERY TKD Italia).
- TA-200-KA Quick coupling surgical sonic handle with 5000 Hz to 9000 Hz oscillating frequency (MICRON CORPORATION 2-17-7, Ikegami, Ota-ku, Tokyo, 146-0082, Japan)

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Figure 1 Surgical sonic handles TA-200-KA MICRON corp. Japan ;SF1L/M Komet Italia; SONOSURGERY TKD Italia

The only setting that was modified in each case depended from the amplitude indicated case by case [5].

SURGICAL IRRIGATION:

Surgical irrigation was granted by NaCl 0,9% sterile solution. An external sterile irrigation system (OMNIFUSER OMNIA) was connected to a sterile multiflex type quick coupler (Sonosurgery® STERIL TKD) or to a sterile tip adapter (SF1979 Komet).

Surgical irrigation was activated depending on clinical pattern and needs. E.gIn case of bony surgery, in order to avoid high temperature (Erikson et al). (Figure 2,3)

Figure 2 and 3 sterile irrigation connection systems available for sonic instruments : A at the end of the sonic handle through a sterile tip sonic adapter(SF1979 Komet).B At the basis of the sonic handle through a multiflex type quick coupler (Sonosurgery® STERIL TKD).

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SONIC TIPS USED BY CLINICAL APPLICATION

Sonic sterile surgical tips were used during surgical procedures. Tips were connected and removed to sonic handle by using a proper dynamometric torque wrench (SF 1975 Komet).

In case of post-extractive alveolar socket regeneration and GBR procedures conical shaped diamond coated tips were used SFS110.000; SFS 68 SFS 99.000.014 (Komet) for bone perforation. (Figure 4)

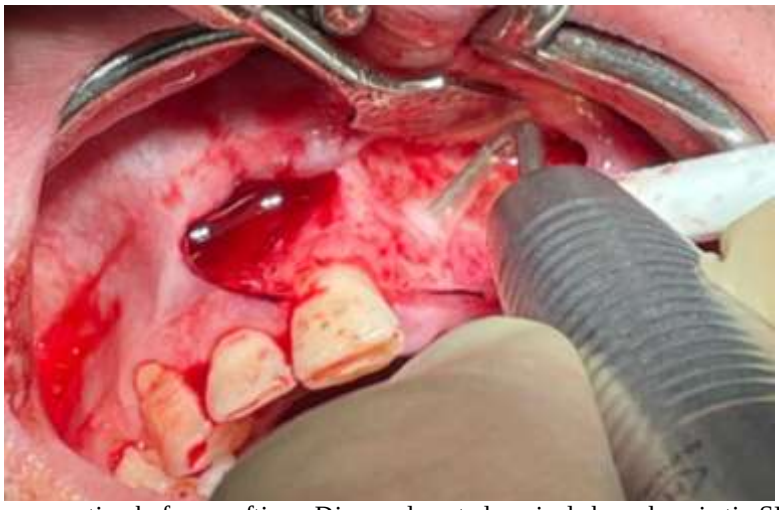

Figure 4. Bone site preparation before grafting . Diamond coated conical shaped sonic tip SFS 68.000 is used. (LEV 2-3)

A conical shaped rough diamond coated tip was used for osteoplasty, bone trimming, bone and alveolar socket debridement SFS 99.000.033 a 60° angulated "trumpet" tip 3,5x5,2mm diameter was used for graft positioning and condensation SFS105.000.

For bone chips harvesting following tips were used applying a gently pressure SF10 L; SF10R ; SF103.000 ; SF104.000; SF 105.000.

For bone block harvesting micro saw-type sonic tips were used do access bone incisions (SFS100 SFS 101). Bone block elevation has been obtained using angulated 75° SFS103.000 and 35° SF104.000 sonic elevators. Diamond coated thin conic tip (SFS 68) was then used to prepare holes for fixation screws both on bone block graft and on receiving native bone. (Figure 5 and 6)

Figure 5 and 6. A bone block harvested from mandibular ramus. Horizontal and vertical incisions are performed with SF100 and SF 101 micro sawsonic tips (Lev 3). Bone block Is gently and precisely drilled with SF68 diamond coated sonic tip (Lev 2)

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Conical shaped diamond coated tip SFS110.000 and SFS68.000 were used also in case of pin tunnel preparation before membrane stabilization and in case of fixation screw tunnel preparation. (Figure 7 and 8)

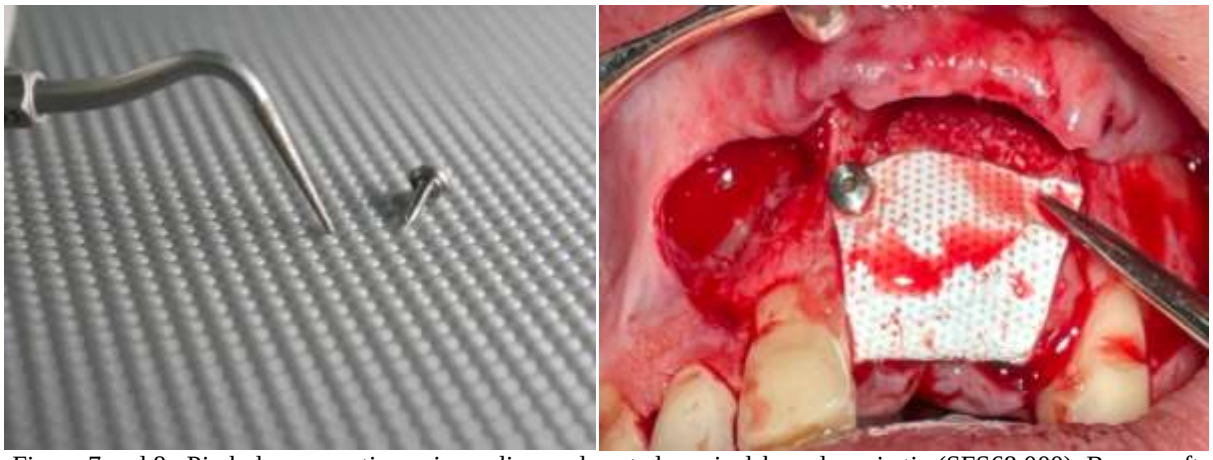

Figure 7 and 8. Pin hole preparation using a diamond coated conicalshaped sonic tip (SFS68.000). Bone graft and non resorbable membrane is positioned and secured with pins.

For Sinus lift procedure with crestal approach, a 2.5 mm round shaped diamond coated tip with internal irrigation was used SFS109.000.025. Tip wase used to access to sinus floor and to obtain an indirect hydrodynamic membrane elevation.

In case of sinus lift procedure with crestal approach contextual to implant positioning, depending on ridge volume, implant tunnel definition and first access to sinus floor was obtained using conical shaped rough diamond coated tips . SFS110.000 SFS 99.000.014 , SFS99.000.018, SFS99.000.021 (Komet) SFS99.000.027, SFS99.000.030 , SFS 99.000.033 , SFS99.000.036. Access to sinus floor and indirect hydrodynamic membrane elevation was reached by mean of a 2.5 mm round shaped diamond coated tip with internal irrigation SFS109.000.025. (Figure 9,10,11 and 12)

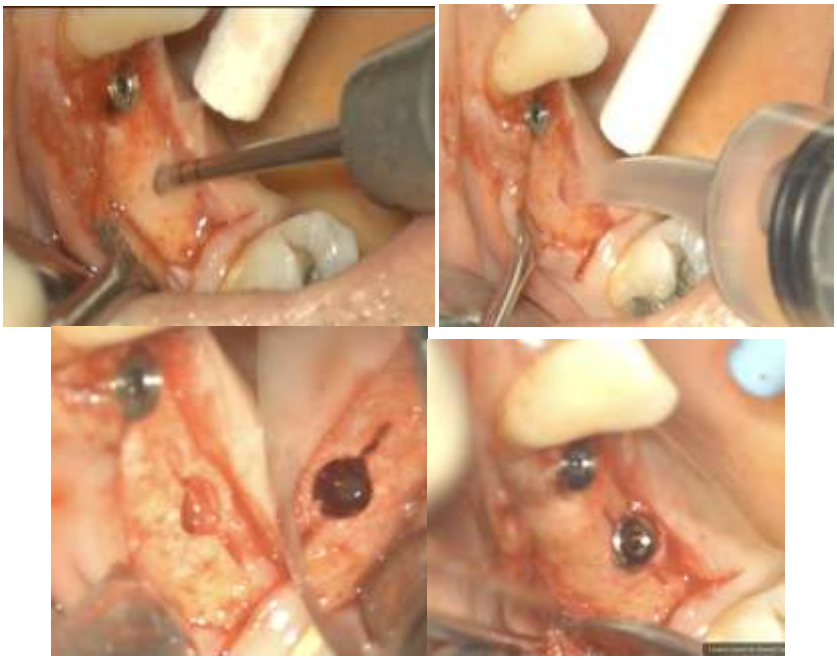

Figure 9,10,11,12. Transcrestal sinus lift. A Diamond coated round tip with internal irrigation is used to access the sinus floor without damaging the sinus membrane and for initial membrane elevation .(SFS 109 LEV 3-1) B Sinus membrane elevation with sterile NaCl solution. C Intact Sinus Membrane after elevation. Implant fixture positioning after sinus grafting.

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For Sinus lift procedure with lateral approach, a 2.5 mm round shaped diamond coated tip with internal irrigation was used SFS109.000.025 for bone window incision and for initial membrane separation. Membrane separation and elevation was obtained using angulated periosteal/membrane sonic elevators 75° SFS103.000 and 35° SF104.000. A 60° angulated "trumpet" tip 3,5x5,2mm diameter was used for membrane separation and bone window elevation SFS105.000 . A 60° angulated "trumpet" tip 3,5x5,2mm diameter was used for bone graft positioning and condensation SFS105.000. (Figure 13 and 14)

Figure 13 and 14. Lateral access SINUS LIFT with sonic instruments. SFS access to maxillary sinus. Sonic trumpet tip

In case of two stage ridge expansion, depending on ridge volume and mandibular location, ridge received a first horizontal incision apically located to implant positioning area with micro-saw sonic tip (SFS 100 and SFS 101) as suggested by Agabiti 30-40 days after first surgery , implant tunnel definition was obtained using conical shaped rough diamond coated tips SFS110.000 SFS 99.000.014 , SFS99.000.018, SFS99.000.021 (Komet) SFS99.000.027, SFS99.000.030 , SFS 99.000.033 , SFS99.000.036. [11 Alveolar ridge received a first horizontal incision of 10 mm depth with micro-saw sonic tip (SFS 100 and SFS 101). Vertical incision were performed with same tips . Motorized conically shaped bone expander were used to obtain a controlled bone plates expansion. Implant fixture positioning concluded the alveolar ridge expansion.

In case of single stage ridge expansion contextual to implant positioning, alveolar ridge received a primary horizontal incision of 10 mm depth with micro-saw sonic tip (SFS 100 and SFS 101). Vertical incision was performed with same tips in case of need. Depending on ridge volume, implant tunnel definition was firstly obtained using conical shaped rough diamond coated tips .(SFS 110 and SFS99SERIES). SFS110.000 SFS99.000.014 , SFS99.000.018, SFS99.000.021 (Komet) SFS99.000.027, SFS99.000.030. Motorized conically shaped bone expander were used to obtain a controlled bone plates expansion. Implant fixture positioning concluded the alveolar ridge expansion. (Figure 15, 16, 17, 18, 19, 20) Single stage ridge expansion contextual to implant positioning.

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Figure 15. horizontal bone incision performed in maxillary bone with micro saw type sonic tip (SFS 101 Lev 3. Figure 16. Motorized bone expansion. Figure 17. Implant fixture positioning.

Figure 18,19,20 Mandibular ridge expansion with sonic instruments and motorized bone expanders.18. Micro saw type sonic tips are used to create bone incisions (SFS 100; LEV3). 19,20. Conical shaped rought diamond coated implant sonic tips are used to create bone expanders and implant fixture hosting tunnels (SFS99 Sono Implant series) .

III. RESULTS

41 patients. (19F; 23 M) (29-81 y.o. ; S.D. 12,64 , mean age 58,09)have been treated for oral surgery bone regeneration procedures. (Table 1)

Table 1

PATIENTS GENDER AND AGE	
PATIENTS TOT	41
GENDER	
F	19
M	23
AGE	
MIN	29
MAX	81
MEAN AGE:	58,097561
DEV ST AGE	12,64279415

Bone regeneration procedures included bone grafting, sinus lifting with lateral access and crestal access, bone fixation, bone block harvesting ,bone chips harvesting andbone expansion .A total of 64 bone regeneration procedures were performed using sonic instruments. Bone regeneration procedures are detailed in Table 2 and Chart 1. Bone grafting (post-extractive alveolar socket regeneration) was performed in 19 cases corresponding to 30 %of cases and resulted in the most frequently performed regenerative procedure. Sinus lifting with crestal

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access resulted in the second most frequently performed procedure with 13 cases corresponding to 20 %. When performed with a lateral approach, sinus lifting was performed in 7 cases (11%). Bone fixation procedure was executed in 5 cases (8%). Bone block harvesting was executed in 3 cases (5%). Bone chip harvesting corresponded to 11% with a total amount of 7 cases. Bone expansion technique with sonic instruments was used in 10 cases (15%).

Table 2

BONE REGENERATION PROCEDURES	n°
BONE GRAFTING	19
SINUS LIFT LA	7
SINUS LIFT CA	13
BONE FIXATION	5
BONE BLOCK HARVESTING	3
BONE CHIPS HARVESTING	7
BONE EXPANSION	10

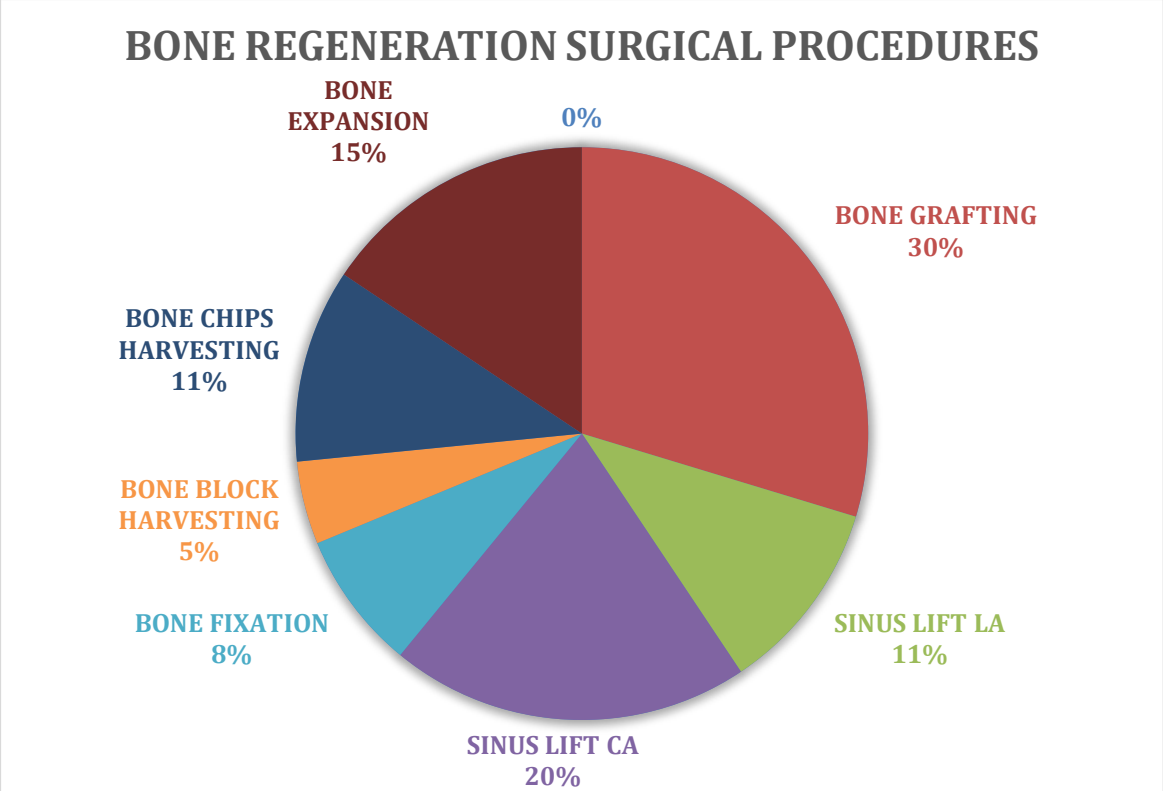

Chart 1

Sterile NaCl irrigation was used in majority of surgical procedure with only exception of bone chips harvesting and partially in bone grafting procedures. In bone grafting procedures sterile irrigation was used in 11 cases on 19. In bone chips harvesting surgical. Sterile irrigation was never used. All remaining bone regeneration procedures were performed with a constant sterile NaCl surgical irrigation. Results are detailed in Table 3, Chart 2,3.

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Table 3

BONE REGENERATION PROCEDURES	n°	IRRIGATION
BONE GRAFTING	19	11
SINUS LIFT LA	7	7
SINUS LIFT CA	13	13
BONE FIXATION	5	5
BONE BLOCK HARVESTING	3	3
BONE CHIPS HARVESTING	7	0
BONE EXPANSION	10	10

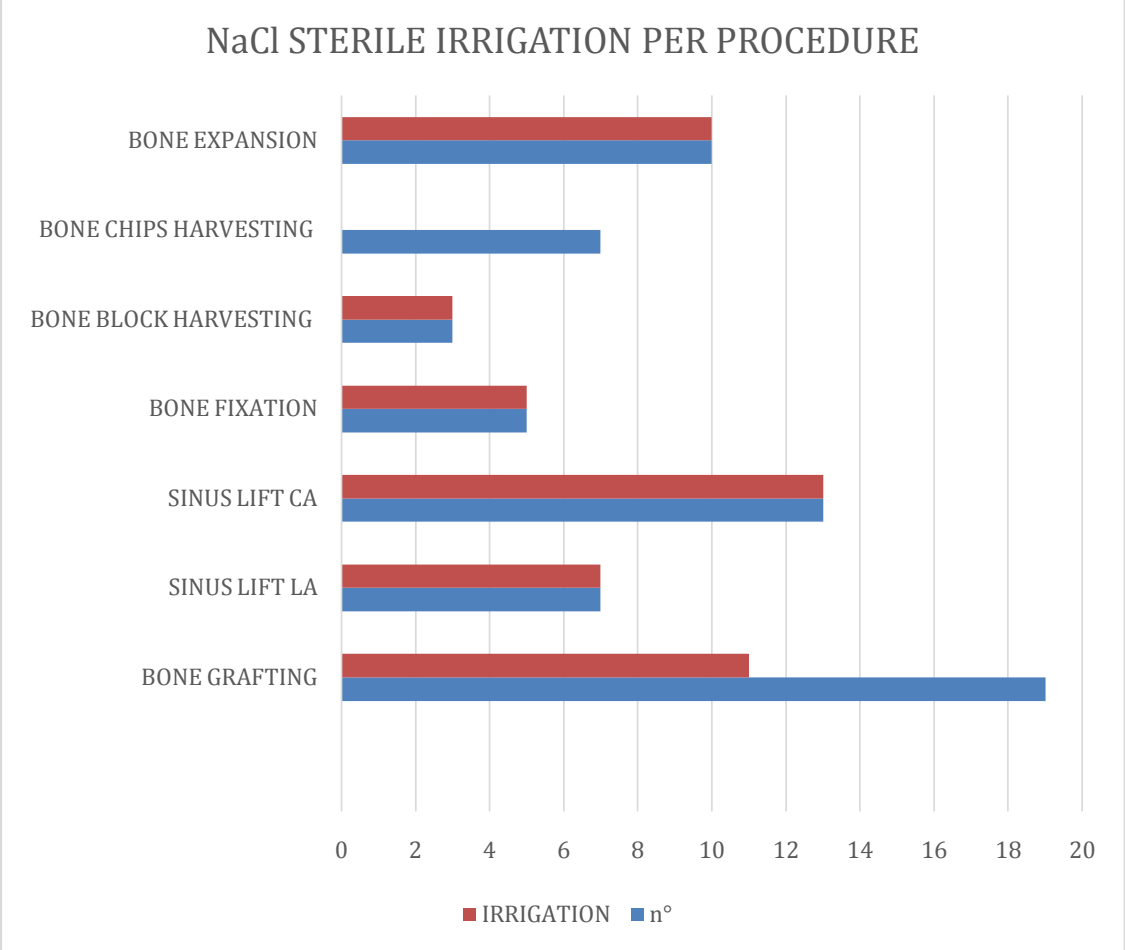

Chart 2NACl Sterile irrigation per procedure.

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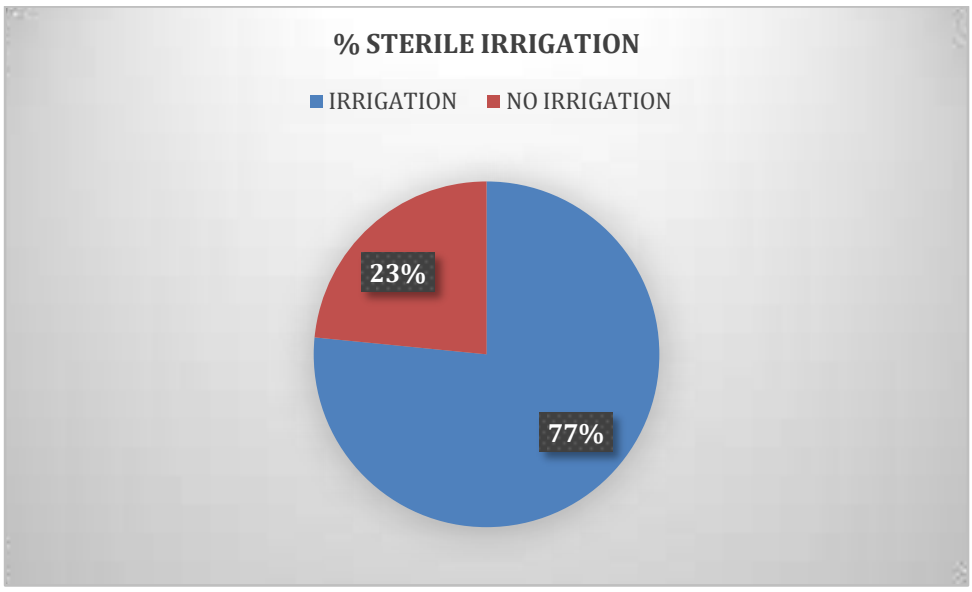

Chart 3 Sterile NaCl irrigation %.

Guided by authors experience and depending on clinical conditions and producer recommendations amplitude of oscillation of sonic tips was regulated in order to provide adequate clinical performance indicated and precision. [5, 14,15,16]

A detailed description of vibration amplitude settings in different clinical intervention is reported in Table 4 and Chart 4.

In bone grafting procedures in 19 cases Level 1 and 2 were selected and in 10 of these Level2.

In sinus lift with lateral access Level 1 and Level 3 were used in 7 cases treated.

In crestal access Level 1 and 3 were selected in all 13 cases.

For bone fixation procedures all 5 cases used a Level 3 setting. For bone block harvesting 3 cases were treated with a Level 3 setting. For bone chips harvesting 4 cases were treated with Level 1 and 3 cases with Level 2 on 7 cases. Bone expansion required Level 3 setting in 10 cases of 10 treated.

Table 4 vibration amplitude settings in different clinical intervention

BONE REGENERATION PROCEDURES	n°	LEVEL1	LEVEL2	LEVEL3
BONE GRAFTING	19	19	10	19
SINUS LIFT LA	7	7		7
SINUS LIFT CA	13	13		13
BONE FIXATION	5	0	0	5
BONE BLOCK HARVESTING	3	0	0	3
BONE CHIPS HARVESTING	7	4	3	0
BONE EXPANSION	10	0	0	10

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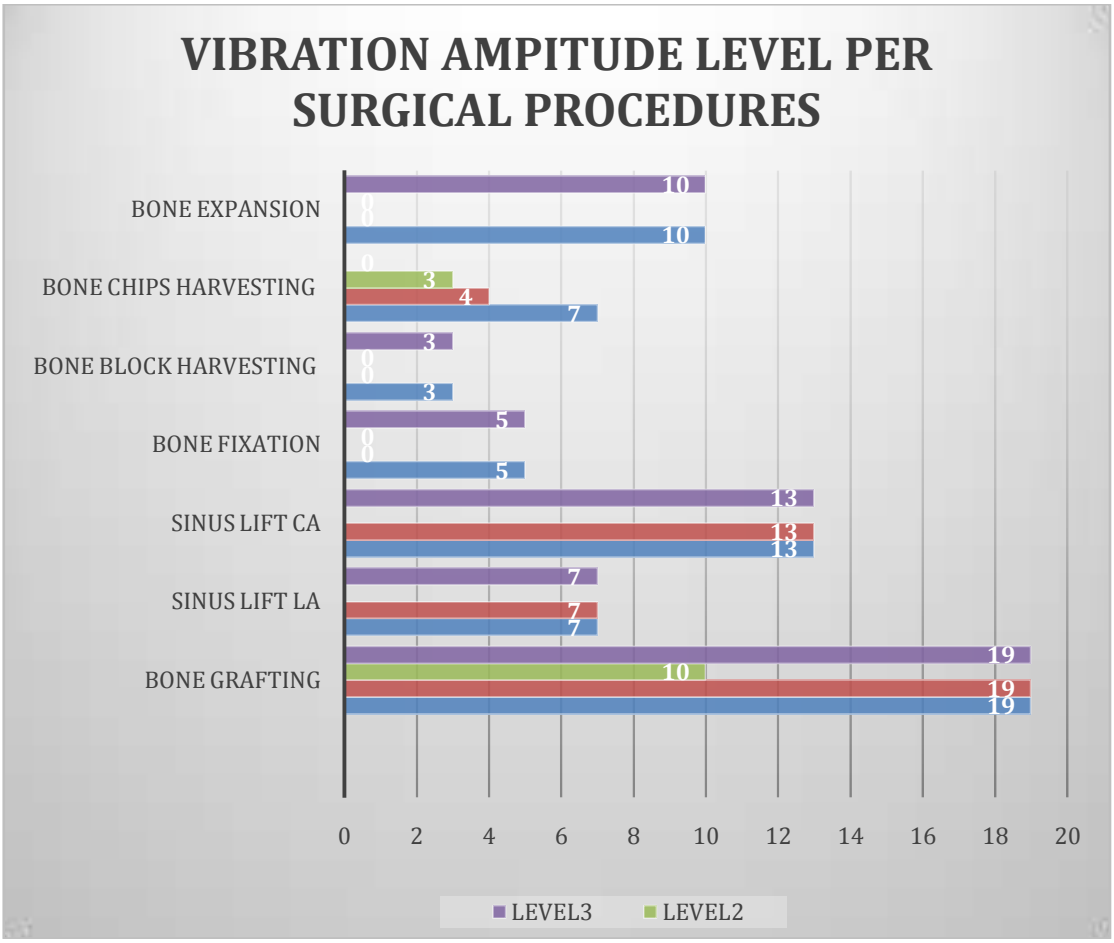

Chart 4 vibration amplitude level per surgical procedure

In 41 patients were performed 64 surgical intervention of bone regeneration (Table 3). 18 Surgical procedures required a single setting (28%) and 46 required multiple setting (72%) (Table 5,Chart 5).

Table 5 Vibration amplitude Level and n° of procedures.

VIBR.AMPLIDUTE LEV.	N°PROCEDURES
SINGLE SETTING	18
MULTIPLE SETTING	46

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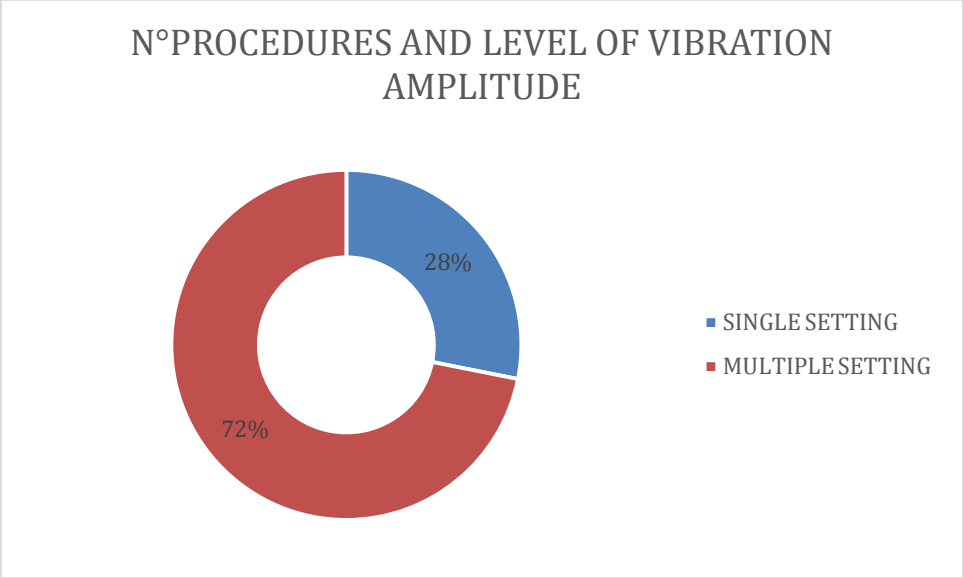

Chart 5 Single setting and multiple setting level of amplitude.

No complication were observed in 64 surgical cases treated (0/64) in 41 patients (0/41).

IV. DISCUSSION

Sterile NaCl irrigation was used in majority of surgical procedure with only exception of bone chips harvesting and partially in bone grafting procedures. Results are detailed in Chart 2, 3.

Only in confined situation in our surgical experience, irrigation was not useful or contraindicated. These cases were represented by cases of bone chips harvesting. Other techniques based on use of piezoelectric instruments use sterile saline irrigation during the procedure and appeal to bone filters applied to surgical suction system [12].To simplify the procedure, in order to avoid bone chips contamination and to avoid bone chips loss and washing is useful to disactivate the surgical irrigation for some seconds until the harvesting is completed.

As long as majority of surgical procedure needs a proper sterile irrigation (77%), it is important to choose a proper irrigation device. Selection or exclusion (23%) of sterile saline irrigation is mainly based on clinical choices and surgeon's experience, never forgetting the importance of maintaining a proper cooling effect and a proper homeostatic ambient for vital bone (Figure 3).

Guided by authors experience and depending on clinical conditions and producer recommendations amplitude of oscillation of sonic tips was regulated in order to provide adequate clinical performance indicated and precision. [5, 14,15,16] .

Standard reference levels are declared by sonic handpiece producers and may vary as indicated in table6. Their frequency ranges between 5.5 and 9 KHz and the tip can potentially oscillate between 60 µm and 1000 µm, generally between 120µm and 240 µm as specified by various producers [13] (Table 6).

Table 6

Output Level	Amplitude	Frequency	Indications
Level 1	120 µm	6000 Hz	Fine finishing and particularly delicate work
Level 2	160 µm	6000 Hz	Preparation and work with medium intensity
Level 3	240 µm	6000 Hz	Powerful preparation and working with (very) high intensity

Table 6, Output levels with characteristics

Scientific literature reports different amplitude of vibration depending on previously cited factors potentially ranging from 100 to 1000 micrometers, generally in the interval of 100-240 micrometers. [3][5]

Based on our findings, majority of surgical procedures performed required a multiple setting value in vibration amplitude. While only 28% required a single setting, over 72 % required two or more distinct setting value. It is highly recommended to choose a proper sonic handle capable to vary the amplitude value. In our configuration by acting on a proper selection ring at the base of the surgical handpiece it was possible to change the vibration amplitude level. Vibration amplitude level may vary depending on shape and length of cutting sonic tips.

V. CONCLUSIONS

There is actually a lack of scientific literature about sonic instruments applied in bone regeneration procedures, especially compared to ultrasonic instruments. Settings of sonic handpiece and its configuration during surgical procedures is generally provided by producers and rarely described in literature.

We described through a case series an overview of possible applications of air driven micro-oscillating sonic instruments in bone regeneration procedures, detailing use of sonic handles, tips and their settings for specifical procedures investigating for any complications.

Modern sonic handpiece can be applied with success in bone regeneration procedures without any complications. Oral surgery bone regeneration procedures suitable for sonic instruments include bone grafting, sinus lifting, bone harvesting, bone fixation and expansion. Specifical sonic insert should be used for single application, with proper irrigation and vibration-oscillation amplitude settings. It is therefore important to use sonic handpieces capable of varying oscillation amplitude and provide sterile irrigation if needed.

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CONFLICT OF INTEREST STATEMENT

All the authors have stated explicitly that there are no conflicts of interest in connection with this article.

Emanuele Ruga is scientific consultant for KOMET Italia for study, teaching and development of sonic instruments and tips.

DATA AVAILABILITY STATEMENT

AI NOTES: NO AI technology/software was used to write this article.

ETHICAL APPROVAL AND CONSENT TO PARTECIPATE

All patients provided their informed consent to participate in the study.

All patients provided their informed consent for photo and video documentation.

This investigation did not involve animalsubjects.

As required by applicable local regulations, this study adhered to all local regulatory requirements . The study was conducted in accordance with the protocol, Guidelines for Good Clinical Practice, and the ethical principles laid down in the Declaration of Helsinki.

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